SUBSTITUTE SPECIFICATION

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VOICE COIL FOR DISK DRIVE

RELATED APPLICATIONS

The present application claims priority under 35 U.S.C. § 119(e) from U.S. Provisional Patent Application Serial No. 60/156,411, filed September 28, 1999, which provisional application is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

Field Of The Invention

The present invention relates to disk drives for information storage in computer systems, and more particularly to a coil assembly for a voice coil motor that drives an actuator arm of the disk drive.

Description Of The Prior Art

Most disk drive storage systems include a plurality of disks stacked onto a rotatable spindle and a corresponding number of magnetic heads that read binary digital information from the disks and write such information on them. The magnetic heads lie mounted on sliders that an actuator arm suspends over the surfaces of the disks while the actuator arm lies rotatably mounted to a base member of the disk drive.

A voice coil motor drives the actuator arm; and this motor typically includes permanent magnets mounted to the base member and a wire and bobbin coil assembly mounted on the actuator arm. The forces generated by the interaction between the magnetic field of the coil assembly and those of the permanent magnets drive the actuator arm to various positions over the disks.

The prior art includes a large number of actuator arm assemblies with various coil and magnet arrangements. Some of these assemblies include multiple layers of wire secured to the actuator arm with adhesive and a plurality of permanent magnets disposed proximate the wire. These constructions require complex fabrication procedures; they are susceptible to malfunction; and they do not allow easy miniaturization of the disk drive.

SUMMARY OF THE INVENTION

The coil assembly of the present invention avoids the disadvantages of the prior art constructions. It is a unique single-layer structure that optimizes force vectors and mass distribution. This construction provides a planar coil that allows easy installation

onto an actuator arm, minimizing the cost of manufacture and assembly and enhancing miniaturization of the drive. It is a simple construction that provides consistent and efficient performance.

In accordance with one embodiment of this invention, a voice coil for a disk drive includes a spiral formation of winding of an electrically conductive material. This formation has a generally triangular shape with an open center. First and second active leg portions of the formation curve inward of it, and an inactive leg portion curves outward of it. The cross-sectional area of the coil varies along its length with the segments in the inactive leg portion having a smaller cross-sectional area than those of the remaining active segments. The voice coil is a laminate with the conductive layer disposed between two electrically insulating layers. It lies fixedly secured to a surface of the actuator arm. The method of making this laminate includes securing the conductive layer to an insulating layer, removing selected portions of the conductive layer to form the coil, and covering the conductive layer with another insulating layer.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of this invention, one should now refer to the embodiment illustrated in greater detail in the accompanying drawings and described below by way of an example of the invention. In the drawings:

FIG. 1 is a perspective view of a disk drive that includes the voice coil of the present invention;

FIG. 2 is a sectional view taken along line 2-2 in FIG. 1;

FIG. 3 is a sectional view taken along line 3-3 in FIG. 2; and

FIG. 4 is a sectional view taken along line 4-4 in FIG. 2.

While the following disclosure describes the invention in connection with one embodiment, one should understand that the invention is not limited to this embodiment. Furthermore, one should understand that the drawings are not to scale and that graphic symbols, diagrammatic representatives, and fragmentary views, in part, may illustrate the embodiment. In certain instances, the disclosure may not include details which are not necessary for an understanding of the present invention such as conventional details of fabrication and assembly.

DETAILED DESCRIPTION

Turning now to the drawings and referring specifically to FIG. 1, a disk drive apparatus A includes an actuator 10 with an arm 11 which supports the voice coil assembly 12 of the present invention and a pivot assembly (not shown) which pivotally

connects the actuator 10 to a base of the disk drive apparatus A. Permanent magnets (not shown) disposed on the base provide a magnetic field that interacts with the magnetic field provided by the voice coil assembly 12 to drive the actuator to various positions over a disk D of the disk drive apparatus A.

The actuator 10 of this disk drive apparatus A is a planar structure suited for use in a single disk system. However, the voice coil assembly 12 may alternatively operate in other actuator constructions, including those used in multi-disk systems. The arm or base 11 of the actuator 10 is a flat plate-like member made out of aluminum, non-magnetic steel, or any other suitable material.

The voice coil assembly 12 is a laminate structure with a bottom, electrically insulating layer 14, a middle, electrically conductive layer 15, and a top, electrically insulating layer 16. The bottom and top layers may be polymide or any other suitable material while the middle layer may be copper or other conductive material. A laminating adhesive secures one layer to another layer as well as the bottom layer to the arm 11.

The conductive layer 15 is a single, spiraling trace that forms a generally triangular band 17 with an open center, first and second active legs, 15a and 15b, an inactive leg 15c, a first curved corner portion 15d connecting the first and second active leg portions, a second curved corner portion 15e connecting the first active leg portion with the inactive leg portion, and a third curved corner portion 15f connecting the second active leg portion with the inactive leg portion. The first and second active leg portions, 15a and 15b, curve inwardly of the band while the inactive leg portion 15c curves outwardly of it. (Also, although not necessary, the average radius of curvature of the first curved corner portion is greater than the average radius of curvature of the second and third corner portions; and the average radius of curvatures of the second and third corner portions is substantially the same.)

As shown in FIG. 2, the first and second leg portions of the band 17 each have a predetermined width W' while the third leg portion has a width W which is smaller in magnitude than the width of the first and second leg portions. While the spacing between each loop of the trace remains substantially the same throughout the trace, as does the height of the trace, the width varies, with the segments defining the third leg portion being substantially smaller than the segments defining the first and second leg portions (see FIGS. 3 and 4).

The pivot axis of the actuator 10 lies outwardly of the voice coil assembly 12 proximate the first curved corner portion 15d. Since the third, inactive leg portion lies the furthest of the three legs from the pivot axis, it makes a substantial contribution to

actuator inertia. However, it does not provide any torque in the desired direction of rotation of the actuator because it directs the force that it generates towards the actuator pivot. A reduction in the trace width (or cross-sectional area) in the third leg portion results in a reduction in mass and inertia. However, the reduction in the width is not of a magnitude that would cause a significant increase in the resistance in this portion of the trace.

As described above, the first and second leg portions curve inwardly of the band 17. This "concave" configuration aligns the electromotive force vector better than straight or convex legs. This configuration provides a higher torque constant (K_t) than does the configuration of a conventional coil with a similar size.

The method of making the voice coil assembly 12 includes the following steps: securing a sheet of material (e.g., copper) that comprises the middle layer 15 to the bottom layer 14 (as with adhesive), removing (as with photo-etching) portions of the middle layer to form a single trace of varying cross-sectional area, and securing (as with adhesive) the top layer 16 to cover the band 17. The next step in this process includes securing (e.g., with adhesive) the bottom layer 14 to the arm 11.

By way of a specific example for a 3.5 inch disk drive form factor, a voice coil of the present invention was constructed with a bottom polymide layer having a height of 1 mil, a middle copper layer of 1.5 mil and top polymide layer of 1 mil. The maximum width T_1 for the trace in the first and second leg portions was 5 mil with a maximum spacing S between adjacent loops of 3 mil (see FIG. 3). The maximum width T_2 for the trace in the third, inactive leg portion was 3 mil with a maximum spacing S between adjacent segments of 3 mil (see FIG. 4).

While the above description and the drawings disclose and illustrate one embodiment, one should understand, of course, that the invention is not limited to this embodiment. Those skilled in the art to which the invention pertains may make other modifications and other embodiments employing the principles of this invention, particularly upon considering the foregoing teachings. Therefore, by the appended claims, the applicant intends to cover any modifications and other embodiments as incorporate those features which constitute the essential features of this invention.